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Soil Erosion and Sediment Delivery in the Highland Silver Lake Watershed, Madison County Illinois: Preliminary Analysis

Illinois State Environmental Protection Agency
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Soil Erosion and Sediment Delivery in the Highland Silver Lake Watershed

Madison County, Illinois

Preliminary Analysis

Division of Water Pollution Control
Illinois Environmental Protection Agency
2200 Churchill Road
Springfield, Illinois 62706

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This report is a product of the Comprehensive Monitoring Evaluation Program for the Highland Silver Lake Watershed Rural Clean Water Project. This study integrates the results of computerized geo-based generated potential gross erosion inventory (ADAPT) and a lake sedimentation survey. The goal was to determine a sediment delivery ratio. This study concluded that the gross erosion for the watershed is 100,973 tons. This erosion data was correlated with lake sedimentation duly from Highland Silver Lake in order to determine the sediment delivery ratio. The ratio was calculated to be 47%.

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PREFACE

This report is a product of the Comprehensive Monitoring and Evaluation Program for Highland Silver Lake Watershed. This program is one of five in the nation designed to evaluate the effectiveness of the U.S. Department of Agriculture (USDA) Rural Clean Water Program in (a) achieving improved water quality in an approved project area in the most cost-effective manner possible in keeping with the provision of adequate supplies of food, fiber and a quality environment, and (b) assisting agricultural landowners and operators to reduce agricultural non-point source water pollutants and to improve water quality in rural areas to meet water quality standards or goals.

Funding for the Rural Clean Water Program and Comprehensive Monitoring and Evaluation Program is provided by the USDA Agricultural Stabilization and Conservation Service. The U.S. Environmental Protection Agency is assisting USDA in evaluating the effectiveness of the Rural Clean Water Program in improving water quality. The USDA Soil Conservation Service, which provides technical assistance in the Rural Clean Water Program, is also responsible for oversight of the Comprehensive Monitoring and Evaluation Program. The University of Illinois Cooperative Extension Service provides education/information assistance in both programs.

Agencies participating in the Comprehensive Monitoring and Evaluation Program include: the Illinois Environmental Protection Agency, which is responsible for water quality monitoring and evaluation; the Illinois State Water Survey, responsible for water quality monitoring and evaluation; the USDA Economic Research Service, responsible for the socio-economic evaluation of the project with assistance provided by the University of Illinois - Department of Agricultural Economics, on the on-farm economic analysis; and the Southwestern Illinois Metropolitan and Regional Planning Commission, on the off-site economic analysis. The Commission is also responsible for coordination of the Comprehensive Monitoring and Evaluation Program, the University of Illinois - Agricultural Experiment Station and the Illinois Department of Conservation are providing voluntary assistance on various aspects of the program.

The Illinois State Rural Clean Water Coordinating Committee is providing oversight for the Highland Silver Lake Watershed Rural Clean Water Program and assisting USDA and EPA in their comprehensive, joint water quality monitoring and evaluation, including coordination with the local coordinating committee. Membership of the Illinois State Coordinating Committee consists of the following:

Illinois State ASC Committee
Farmers Home Administration
Cooperative Extension Service
U.S. Forest Service
Soil Conservation Service
U.S. Environmental Protection Agency - Region V
Illinois Environmental Protection Agency
Illinois Department of Agriculture, Division of Natural Resources
Illinois State Water Survey
Illinois Department of Conservation
Economic Research Service

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The guidance and assistance provided by the United States Department of Agricultural-Soil Conservation Service (SCS) under the direction of State Conservationist, John J. Eckes, is gratefully acknowledged. Specifically, Ron Murphy, Wayne Kinney, Steve Probst, Lee Bridgemen and Dana Walker of the SCS were very helpful. Lee Rogers, Nancy Wiemers, Audrey Renken (ASCS) and Jim Kiejei (ICES) provided assistance in this project. Mary Clement, SIMAPC, provided coordination.

Portions of this report were taken from reports and materials prepared for individual specific activities by William Bogner, (ISWS) and W.E. Gates and Associates.

John Little of the Illinois Environmental Protection Agency (IEPA) provided technical assistance throughout this project. The editorial comments of Robert Clarke, and William Rice (IEPA) are greatly appreciated. This report was typed by the Word Processing II Unit under the direction of Norma Kraus and printed by the Print Shop under the direction of Claude Pearson. Mary Anderson and Karen Janssen assisted in report preparation. Gloria Ferguson created the cover and assisted with the graphics. Nancy Simpson and Susan Carlson assisted in the collection of the literature.

EXECUTIVE SUMMARY

1. Background: The Illinois Environmental Protection Agency (IEPA) in cooperation with various State and Federal agencies, is evaluating the impact of Resource Management Systems (RMS's) implemented under the Rural Clean Water Project in the the Highland Silver Lake Watershed, Madison County, Illinois. The primary objective of this project is to identify the most viable agricultural non-point source (NPS) control strategy, demonstrate its effectiveness, and develop a methodology to identify land causing water quality problems and to determine the appropriate RMS's.

2. Investigation: Adequate control of agricultural non-point source pollution requires an effective and efficient management program. An integral component of this is the identification of those areas which act as sources of non-point source pollution. Specific areas that contribute to non-point source pollution must be identified in order to direct programs and practices to correct the problem areas. This study integrates the results of a computerized geo-based generated potential gross erosion inventory (ADAPT) and a lake sedimentation survey. The goal was to determine a sediment delivery ratio in an attempt to identify sediment source areas.

3. Systems: ADAPT (Areal Design and Planning Tool) a geo-based computer mapping and planning system was utilized. This computerized system generated potential gross (sheet and rill) erosion for specific land use/cover designations. Land use/cover was delineated by individual farm-field boundaries. The pre-project, most practical, most likely and best possible land management conditions were delineated by a local agency personnel. For each land management unit the four management conditions were defined.

   A sedimentation survey was conducted on Highland Silver Lake in 1981 by the Illinois State Water Survey. Sounding data from 15 cross sections were collected in the 1981 survey.

4. Conclusions: This study concluded that the annual gross erosion for the Highland Silver Lake Watershed is 100,973 tons. This erosion data was correlated with lake sedimentation data from Highland Silver Lake in order to determine the sediment delivery ratio. This ratio was calculated to be 47%.

   Currently, 0.69% per year of lake capacity is lost to sedimentation. Under these conditions the lake will be completely filled in 145 years. Under "most practical" management conditions, the life of the lake would gain 125 years, under "most likely" conditions the life of the lake would be extended by 54 years and under "best possible" the lake would gain 208 years.

Soil Erosion and Sediment Delivery in the Highland Silver Lake Watershed

Introduction

The Federal Clean Water Act of 1977, Public Law 95-217, has mandated pollution abatement efforts directed toward controlling pollution at their sources rather than after the pollutant has entered the water course. The National Pollutant Discharge Elimination System program for control of point source discharges is well underway. The development of the "208" planning process has placed the emphasis on nonpoint pollution control. Programs must be developed and implemented to minimize water quality degradation resulting from nonpoint pollutants.

Nationwide, agriculture is the most widespread nonpoint source of water pollution across the nation. Initial water quality management planning efforts documented that agricultural activities are a major source of pollution in Illinois and mandated the development of plans to control this nonpoint source pollution from agriculture. The most severe agricultural related problem is soil erosion resulting in sedimentation. The total volume of eroded material has been estimated to be 700 times more than point source contribution (Johnson, 1970; Stewart, 1975). In Illinois estimated gross erosion exceeds 180 million tons annually, with 158 million tons from sheet and rill erosion from cropland (IEPA, 1979).

To control agricultural nonpoint pollution from the source, effective and efficient land management practices and programs must be developed. A fundamental component of these programs is the identification of specific areas that significantly contribute to the problem. The ability to identify and quantify "source" areas allows for targeting of resources and programs to correct the problem areas.

Erosion is defined as the detachment and movement of soil or rock fragments by water, wind, ice or gravity. Water is the most widespread agent of erosion and accounts for the bulk of sediment transport (Gottschulk, 1964). There are five principal types of water erosion: 1) gully; 2) natural; 3) rill; 4) sheet; and 5) splash erosion. Two types of water erosion were estimated in this study: sheet and rill (Figure 1). For this study, the term erosion refers only to those two.

Soil erosion has several major consequences: 1) the original sites of the eroded material are degraded, therefore potential productivity is lessened; 2) the sites of deposition of the soil particles are altered physically, chemically and hydrologically, and 3) the chemical and physical nature of the transporting water system is drastically affected (Meyer, 1971). Economic values related to these three major consequences are difficult to assess due to the relationship between soil particle size and the type of damage caused. Degradation of the productive capacity of agricultural land results in depletions of yield. However, the most serious problem with erosion is the deteriorating off-site effect it has on the aquatic environment. Runoff from agricultural land can carry soil particles, nutrients, pesticides, fertilizers, livestock wastes and other pollutants to the receiving water. This runoff,

carrying large amounts of suspended soil particles scours the stream channel, alters the character of the stream, and affects aquatic life by impairing functions such as photosynthesis, respiration, growth and reproduction.

Sediment is defined as any solid material, either mineral or organic, which has been eroded, transported and deposited on land or in water (Steehais, 1979). Sediment is a significant pollutant because of its physical properties, potential chemical interactions and total loads. Suspended solids carries pollutants such as pesticides, nutrients and trace metals, causing water quality problems. Suspended matter impacts freshwater ecosystems biochemically, chemically, physically, and biologically (Table 1). Suspended matter can increase the cost of obtaining a suitable water supply for some users. The National Academy of Science -- National Academy of Engineering Committee's (NAS-NAE) Working Party on Water Quality Criteria for European Freshwater Fish has arbitrarily defined four degree of risk to fisheries categories and estimates of the range of suspended solid concentrations that corresponds to each;

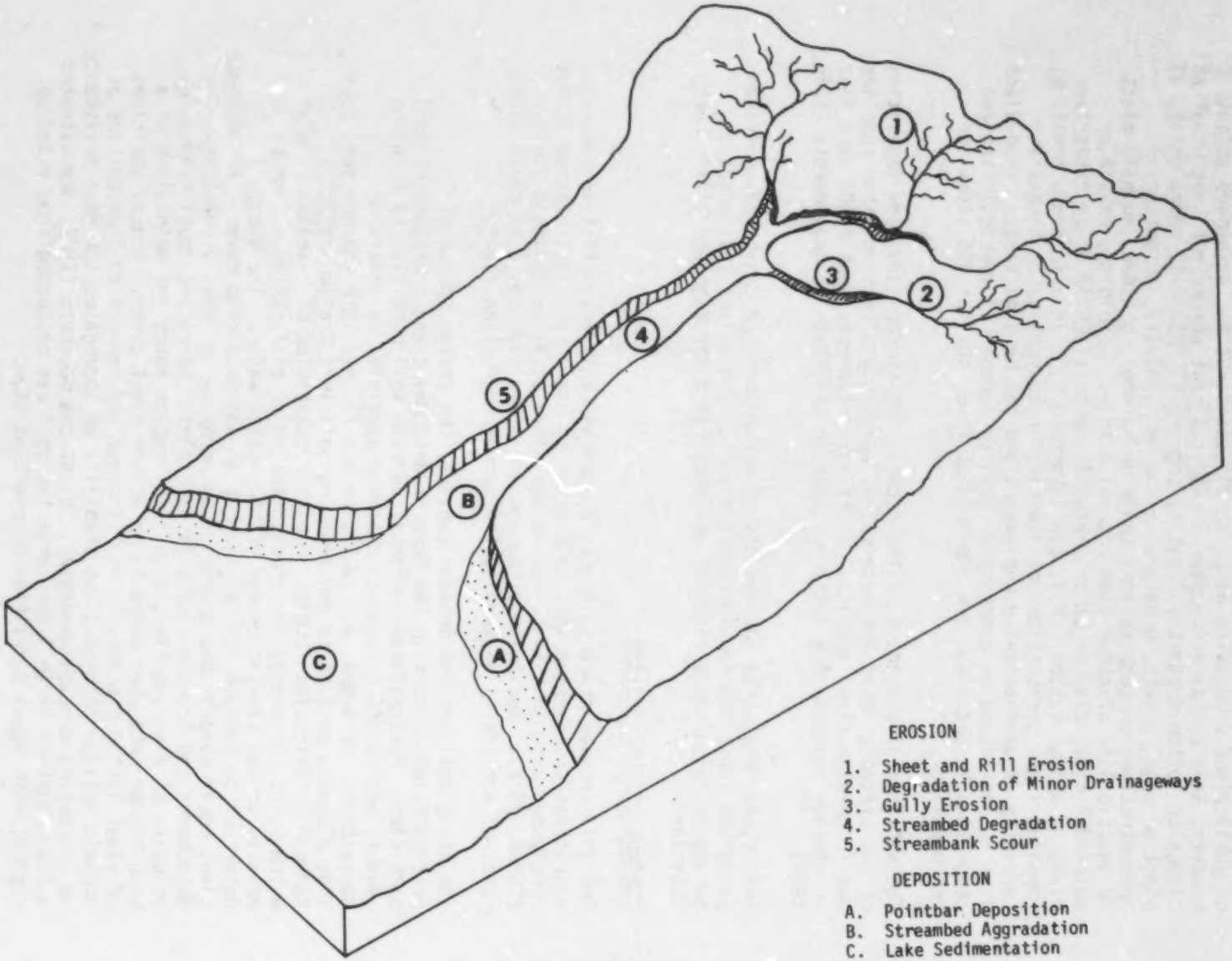
(1) There is no evidence that concentrations of suspended solids less than 25 mg/l have any harmful effects on fisheries.
(2) It should usually be possible to maintain good or moderate fisheries in waters which normally contain 25-80 mg/l suspended solids. Other factors being equal, however, the yield of fish from such waters might be somewhat lower than from those in category (1).
(3) Waters normally containing from 80-400 mg/l suspended solids are unlikely to support good freshwater fisheries, although fisheries may sometimes be found at the lower concentrations within this range.
(4) At the best, only poor fisheries are likely to be found in waters which normally contain more than 400 mg/l suspended solids." (NAS-NAE, 1972).

TABLE 1

Classification of suspended matter and their major impacts on freshwater ecosystems (Mulkey, 1977).

Type of Matter	Biochemical, chemical and physical effects	Biological Effects
natural inorganic material (clay, silt, sand)	Sedimentation, erosion and physical abrasion, turbidity (light penetration, habitat change)	Respiratory interference, habitat destruction, light limitation
natural organic matter	sedimentation, dissolved oxygen utilization	food sources, dissolved oxygen effects

Figure 1. Erosion and Deposition Occurrence Diagram.



EROSION

1. Sheet and Rill Erosion
2. Degradation of Minor Drainageways
3. Gully Erosion
4. Streambed Degradation
5. Streambank Scour

DEPOSITION

A. Pointbar Deposition
B. Streambed Aggradation
C. Lake Sedimentation

The Illinois Pollution Control Board (IPCB) has not specified general use or public/food processing water supply standards for suspended solids. However, Rule 203(a) of Chapter 3 requires that waters not have unnatural sludge or bottom deposits, floating debris, visible oil, odor, unnatural plant or algal growth, unnatural color or turbidity, or matter in concentrations or combinations toxic or harmful to human, animal, plant or aquatic life of other than natural origin. Turbidity, caused by suspended silt, clay or other inorganic material (NVS) or by excessive plant or animal matter (TVS), can interfere with aquatic productivity by impeding light penetration and limiting photosynthesis. Excessive turbidity is aesthetically unpleasing and can be a nuisance. When plant life is diminished in quantity or quality (number of species) fish and other aquatic organisms are deprived of food, shelter and sites for reproduction.

The settling of suspended solids reduces the storage and flow capacities of our streams, lakes and reservoirs, adversely affecting water supplies and increasing flood potential. Estimates indicate that 8,000 acre feet of storage capacity are lost each year in the State's impoundments (IEPA, 1979).

This study integrates the results of a computerized geo-based generated potential gross erosion inventory (ADAPT), and a lake sedimentation survey to calculate a sediment delivery ratio for Highland Silver Lake Watershed.

CONTROL OF SOIL EROSION

The soil erosion process is accelerated by man's activities or natural catastrophies, causing soil loss rates to escalate. Soil erosion is not synonymous with soil loss, nor is soil loss equal to sediment yield (Dunne, 1978). Agricultural management activities can also cause higher rates of erosion by disturbing the normal vegetation cover.

The basic soil erosion process converts the energy source of precipitation to work in the form of detachment and transport of soil particles. Precipitation detaches surface soil particles by raindrop impact, and runoff transports detached particles to points of deposition. Detached soil particles are flushed into surface soil pores, thus plugging soil pores and reducing soil infiltration capacity. Reduced infiltration results in higher quantities of overland flow at which point the energy for transportation of soil particles can be related to the kinetic energy of the moving water. The greatest deterrent to surface soil erosion is an adequate crop cover. An adequate plant cover absorbs the energy of raindrop impact thus preventing detachment and transport of soil particles. Stems and roots reduce the velocity of overland flow, thus infiltration rates are maintained at a much higher rate when there is an active plant cover. Annual additions of plant litter protect the soil surface and improve soil properties as organic residue increases the stability of aggregates and thus resistance to increasing erosion processes. Borst and Woodburn (1942) demonstrated a 95% reduction in soil loss when the soil was protected from raindrop impact, with equal quantities of overland flow.

It is logical that those land management methods which expose maximum amounts of bare soil will have the larger amounts of soil loss. Agricultural land management which incorporates conservation tillage, contour planting and other best management practices has been effective in reducing soil loss. A land owner/operator has three options to reduce soil loss: (a) employ erosion control practices; (b) switch to rotations that lower soil loss, or (c) convert cropland to pasture.

Soil erosion resulting from agricultural activities is controlled by implementing various conservation practices which lower soil loss rates. Resource Management Systems (RMS) can be implemented by the individual land owner/operator that would reduce soil erosion to more tolerable losses. RMS's must control erosion, effectively utilize rainfall, minimize environmental impact and be practically and economically sound. A list of the approved Best Management Practices for the Highland Silver Lake RCWP Project is presented as Appendix A. Reducing soil erosion on the individual land management units should reduce off-site damages associated with soil loss from agricultural practices. Many RMS's are least effective at controlling the movement of small particles (clay-organic complex) which are important due to their potential chemical interactions. Reduction in soil delivery does not always produce visible improvements in water quality since silt and clay particles appear to be the hardest to control and yet contribute most to water color and turbidity problems.

If on-site erosion is reduced significantly by effective RMS's, less sediment will enter the channel network. Without a comparable reduction in runoff entering these networks, the carrying capacity of streamflow will be greater than the sediment input and an unstable channel will degrade rapidly to adjust gradient and load (Piest, 1974). Sediment-associated water quality at a downstream point may be no different than before RMS's were applied on upland areas (Knisel, 1982).

RMS's can be divided into two groups. The first, cultural practices, are nonstructural in nature. This group includes conservation tillage systems, contouring and stripcropping. The second group consists of structural practices which usually require off-farm equipment for construction. The practices in this group include terraces, diversions, livestock exclusion, grassed waterways, lagoons and filter strips.

The basic principle of the above RMS's are to alter the runoff, provide cover for soil or change the water absorption capacity of soil, rain splash energy, and soil structure. Most RMS's are designed to control either, 1) detachment and transport, or 2) only transport of soil particles.

Economically, the two classes of practices can be distinguished on the basis of both initial and recurring cost. Structural practices are characterized by a relatively high initial cost and lower annual costs, representing the cost of maintenance. Cultural practices, such as the alteration of a tillage system or removal of land from production for

some purpose, have a recurring annual cost based on the value of production lost through the application of the practice. These costs in agricultural situations are dependent on the costs of inputs to farm production and the value of the farm products to be sold (Lake, 1977).

Presently, the United States Department of Agriculture offers technical and/or financial assistance to land owner/operators for the implementation of RMS's within the watershed thru the Rural Clean Water Program (RCWP). However, the implementation of RMS's is strictly voluntary on the land owner/operators part. Even with assistance available from various agencies, the deciding factor is the willingness of the land owner/operator to implement conservation practices.

RURAL CLEAN WATER PROGRAM

The experimental RCWP, was authorized in the Agriculture, Rural Development, and Related Agencies Appropriations Act of 1980 (P.L. 96-108). The objectives of the RCWP are to:

a) Achieve improved water quality in the approved project area in the most cost-effective manner possible in keeping with the provision of adequate supplies of food, fiber, and a quality environment.

b) Assist agricultural land owners and operators to reduce agricultural nonpoint source water pollutants and to improve water quality in rural areas to meet water quality standards or water quality goals.

c) Develop and test programs, policies and procedures for the control of agricultural nonpoint source pollution.

HIGHLAND SILVER WATERSHED PROJECT

The Highland Silver Lake Watershed in Madison County, Illinois (Figure 2) was selected to demonstrate the effects of erosion control practices upon water quality. The project area was designated a RCWP project which provides financial assistance to land owners/operators for the implementation of conservation and pollution control practices. The Illinois Environmental Protection Agency (IEPA) in cooperation with United States Department of Agricultural Agencies; Agricultural Stablization and Conservation Service (ASCS), Economic Research Service (ERS), Soil Conservation Service (SCS), Cooperative Extension Service (CES), Illinois State Water Survey (ISWS), University of Illinois Agriculture Economic Department (U of I) and Southwestern Illinois Metropolitan and Regional Planning Commission (SIMAPC) is evaluating the impact RMS's implemented under the RCWP in the Highland Silver Lake Watershed (Figure 3).

The monitoring and evaluation project's primary purpose is to assess effectiveness of RCWP approach. Monitoring and evaluating of RMS's will document actual impacts from agricultural practices and aid in determining strategies for the implementation of the State Soil Erosion

Figure 2. Highland Silver Lake Watershed, Madison County, Illinois

and Water Quality Program. This study will provide a comparison of cause/effect relationships between various agricultural practices and water quality impacts and an evaluation between high and low cost strategies.

DESCRIPTION OF PROJECT AREA

The Highland Silver Lake Watershed encompasses 30,946 acres in eastern portion of Madison County, Illinois. It drains into Highland Silver Lake through Silver Lake and its numerous tributaries (refer to Figure 1). The Highland Silver Lake Watershed is located approximately one mile northwest of Highland.

Highland Silver Lake, an artificial impoundment, was constructed in 1961 by the City of Highland as a public water supply. It is utilized for recreation and flood control, as well as a water supply for the City of Highland. There is one known municipal discharge to the Highland Silver Lake Watershed, Grantfork Elementary Center, upstream from Highland Silver Lake.

TABLE 2

Land use/cover in the Highland Silver Lake Watershed, 1982, by acres and percent.

Land Use/ Cover	Highland Silver Watershed # of Acres	%
Cropland	25,205	83.3
Past/Hayland	1,662	5.4
Woodlands	1,250	4.1
Urban	210	0.7
Feedlots	116	0.4
Interstate	49	0.2
Wildlife	327	1.1
Farmsteads	619	2.0
Residential	356	1.2
Gravel	15	0.0
Water	830	2.7
Total	30,639	100.0

Agriculture is the predominant land use in the watershed with 88% of the land devoted to row crops (Table 2). Major crops grown in the watershed include corn (8,570 acres), soybeans (12,350 acres) and wheat (4,285 acres). Pasture land comprises an estimated 5% of the watershed (1,662 acres). The principal crop rotations are: corn/soybean; corn/soybean/wheat with double crop soybeans; soybean/wheat/with double crop soybeans; corn/soybean/wheat/meadow and corn/corn/soybeans/wheat and 4 years of meadow. About 4% of the watershed is in woodland (1250 acres). Silver Lake and other small water bodies cover about 3% of the watershed (830 acres). The Village of Grantfork, the only urban area in the watershed comprises about 0.7% of the total acreage (210 acres).

METHODS AND PROCEDURES

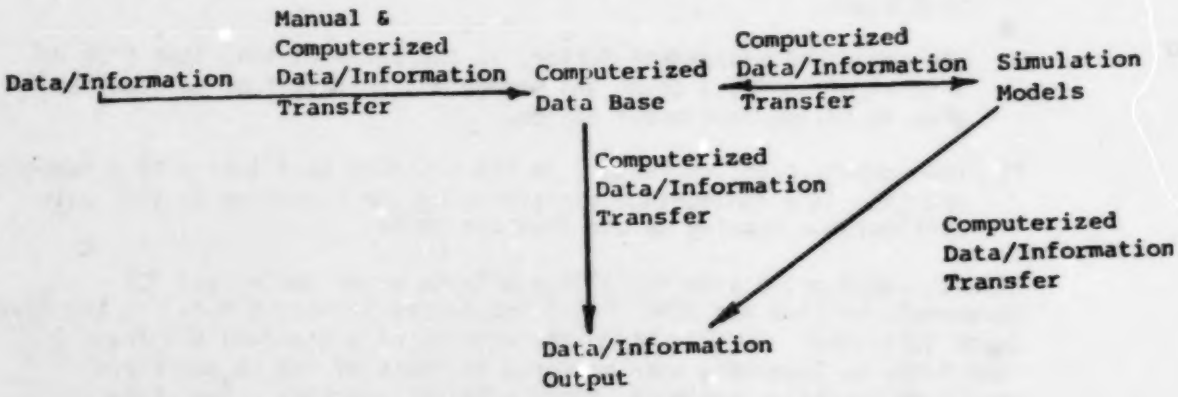
A geo-based computer mapping and planning system was used to determine the potential gross erosion in the Highland Silver Lake Watershed. The computerized method (ADAPT) generated potential gross erosion for specified land use/cover designations.

Computerized Sheet and Rill Erosion Estimation Method

Planning is a process of evaluating the relative effectiveness of alternative management alternatives designed to attain stated goals. One of the most effective methodologies appropriate for planning non-point source pollution control programs is known as simulation. This approach utilized a mathematical model of the system under consideration to evaluate the consequences of alternative control strategies. The validity of pollution control programs developed and implemented using the simulation approach is entirely dependent upon the accuracy with which the model can predict the effectiveness of the control strategies being considered. Therefore, a model capable of accurately simulating a wide range of alternatives is essential if this approach to planning is to be successful (Lake, 1977).

ADAPT (Areal Design and Planning Tool), a geo-based computer mapping and planning system, was utilized for determining potential gross erosion on the Highland Silver Creek Watershed. This computer modeling system represents a synthesis of two popular computer based approaches to analysis and planning: 1) spatial/geographical data base; and 2) analytical mathematical modeling techniques. The ADAPT system is a proprietary system owned by W.E. Gates and Associates, Inc., of Batavia, Ohio.

The basic modules of ADAPT are:



The data/information incorporated into the data base is determined by the needs of a particular ADAPT application. A combination of manual and computer based techniques are used to capture the data/information and transfer it to the computerized data base.

The ADAPT Non-Point Source Screening Model was utilized to estimate the potential gross erosion conditions associated with different land management activities. This model is based on the Universal Soil Loss Equation (USLE), which is an accepted method for estimating the average annual sheet and rill erosion in tons per acre.

The USLE was designed to predict field sheet and rill erosion in tons/acre on an average annual basis and does not predict sediment delivery to streams. The USLE (United States Department of Agriculture, 1977) is applicable to cropland, pasture, woodland, wildlife land, and idle land (see Wischmeier and Smith, 1965, for development and use). The soil loss prediction formula is as follows: A = RKLSCP where A is the average annual soil loss in tons per acre predicted by the equation.

R: the rainfall and runoff factor, is the number of rainfall erosion index units, plus a factor for runoff from snowmelt or applied water where such runoff is significant.

K: the soil erodibility factor is the soil loss rate per erosion index unit for a specified soil as measured on a unit plot, which is defined as a 72.6 ft. length of uniform 9% slope continuously in clean tilled fallow.

L: the slope-length factor, is the ratio of soil loss from the field slope length to that from a 72.6 ft. length under identical conditions.

S: the slope-steepness factor, is the ratio of soil loss from the field slope gradient to that from a 9% slope under otherwise identical conditions.

C: the cover and management factor, is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow.

P: the support practice factor, is the ratio of soil loss with a support practice like contouring, stripcropping, or terracing to that with straight-row farming up and down the slope.

IEPA in cooperation with the Illinois State Water Survey and SCS personnel verified the ADAPT Non-Point Source Screening Model in the Blue Creek Watershed. In this study the results of a Standard SCS Phase 1 Land Resource Inventory were compared to those of the computerized geo-based generated potential gross erosion inventory. The study concluded that ADAPT provided a means for quantifying potential gross erosion as accurately as the traditional field method (Davenport, 1982).

USGS, 7/1/2 minute maps provided the topographical and political boundaries; soil data at the mapping unit level was provided by SCS. Land use/cover in fourteen categories was furnished by the local participants from ground surveys. USLE factors, cropping (C) and conservation practice (P) were representative numbers provided by the local District Conservationist of the SCS. The slope length factor, also obtained from SCS, was a representative slope length for each soil series. List of the C and P numbers, slope length factors, K and T values and the hydrologic soil group number for the field in the watershed are presented in Appendix Section. The percent slope was calculated by the ADAPT System. The soil erodibility factor and the rainfall factor were obtained from Resource Conservation Planning Technical Note - IL-4 (USDA-SCS, 1977).

Land use/cover was delineated by individual farm-field boundaries. The present land management activities were delineated by the local District Conservationist (SCS) and County Executive Director (ASCS). For each field in row crop rotation, the pre-project, most practical, most likely and best possible management practices were defined. A list of the crop rotations, tillage systems, and conservation practices making up these management practices for the fields in the watershed is presented in the Appendix Section. The range of cell size was from 0.05 to 20.0 acres (average = 0.085 acre) for the completed field level data base.

Sedimentation Survey

A sediment survey was conducted on Highland Silver Lake in 1981 by the Illinois State Water Survey. Sounding data from 15 cross sections were collected in the 1981 survey. Figure 3 shows the locations of the lake cross sections.

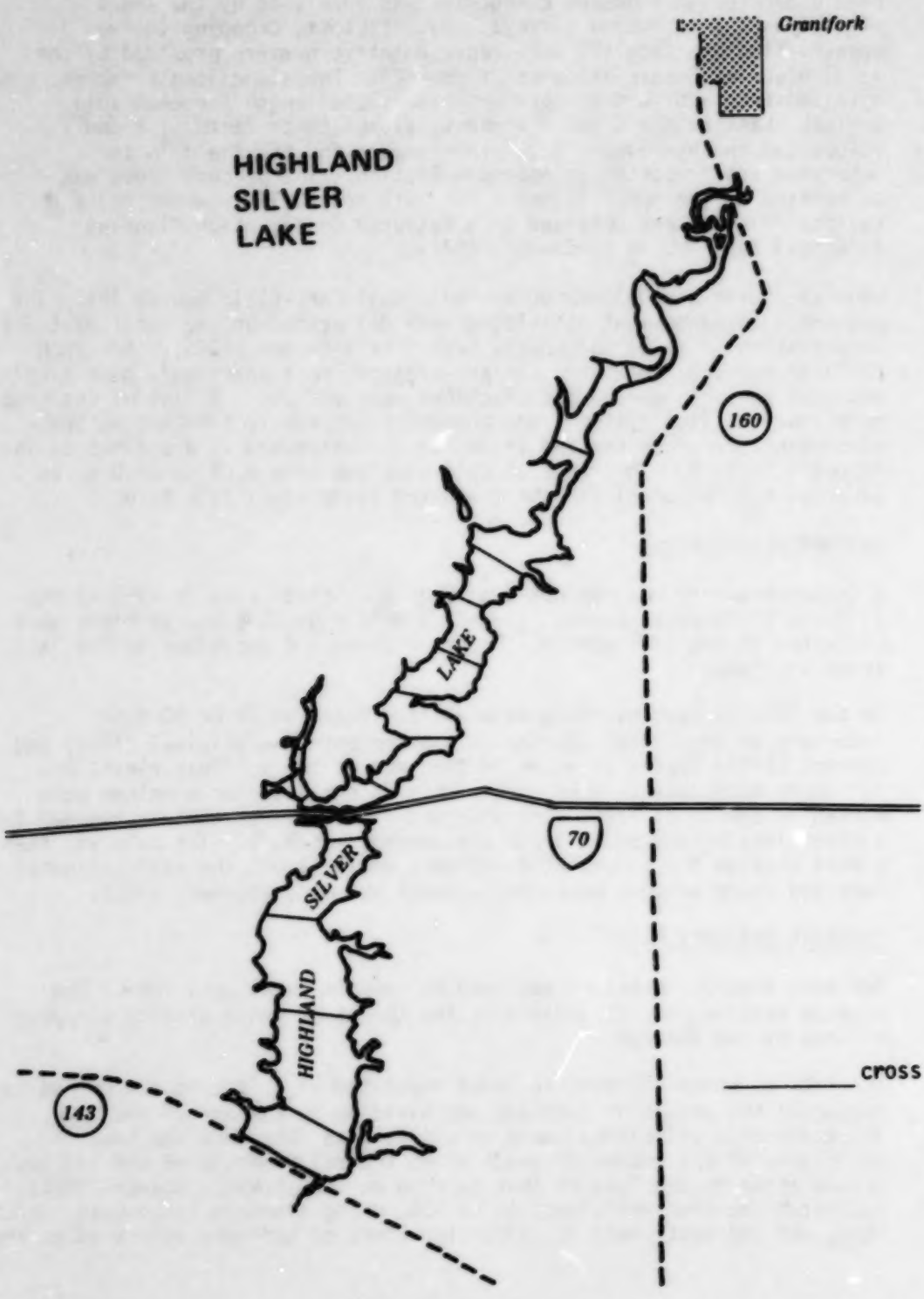
In the 1981 survey, sounding data was collected at 25 or 50 foot intervals on each cross section to measure both the original (1962) and current (1979) depths of water in the lake at the spillway elevation. All depth measurements were made with a 2-inch diameter aluminum pole marked in tenths of feet. The pole was first lowered till it touched the current lake bottom and a depth measurement was made. The pole was then pushed through the accumulated sediment until it hit the solid original lake bed where another depth measurement was made (Bogner, 1981).

Sediment Delivery Ratio

The soil erosion inventory was used to compute total soil loss. The average erosion rate is defined as the amount of gross erosion per year divided by the acreage.

The rate at which sediment is being deposited in a lake is determined by measuring the amount of sediment and dividing by the age of the lake. The Brune trap efficiency curve is utilized to determine the trap efficiency of the reservoir which gives the relationship of the sediment accumulation in the lake to that carried on downstream. Bogner (1981) estimated the trap efficiency to be 93%, using standard techniques. From this, the sediment yield is calculated (tons of sediment delivered to the

Figure 3. Location of Lake Sedimentation Survey



reservoir/year). Finally, the sediment delivery ratio can be determined. This is defined as the ratio of sediment yield to the amount of gross erosion.

RESULTS

Results from the ISWS sedimentation survey are given below. The ADAPT system estimates of sheet and rill erosion are presented in Table 3.

Sheet and Rill Erosion

Potential sheet and rill erosion rates by land use/cover category for the Highland Silver Lake Watershed as determined using the ADAPT system are presented below. The ADAPT system's estimated will be field verified during the upcoming year. The average erosion under the specified present conditions was 3.4 tons/acre.

The average erosion rates on agricultural lands ranged from 17.36 tons/acre for feedlots to 0.2 tons/acre on managed woodland areas. Only feedlots had an annual average erosion over 10 tons/acre. The remaining agricultural land use/cover categories had annual average soil losses under 5 tons/acre. Non-agricultural land use/cover categories annual average erosion rates ranged from 16.3 tons/acre for gravel quarry site to 0.2 tons/acre for the interstate acreage.

TABLE 3

Potential Gross Erosion Rates by Land Use/Cover Category in the Highland Silver Lake Watershed as Determined by the ADAPT System.

Land Management Activity*	No. of Acres	Erosion (Tons)	Erosion (Tons/AC)
Corn-Soybeans	457.4	3458.9	7.56
C-S-W/DBL. Crop Soybeans	18211.6	74268.8	4.08
S-W/DBL. Crop Soybeans	2093.1	4411.5	2.11
C-S-W-M	2951.5	9345.8	3.17
C-C-S-W-M-M-M-M	1491.3	3694.5	2.48
Perm. Grassland (Good)	509.0	221.9	0.44
Woodland (managed)	1228.3	206.3	0.17
Woodland (unmanaged)	22.2	25.5	1.15
Wildlife	327.4	459.5	1.40
Urban Areas	210.3	112.6	0.54
Feedlots	116.3	2019.2	17.36
Farmsteads	618.8	927.7	1.50
Residential (low dens.)	355.9	269.9	0.76
Perm. Grassland (Poor)	1152.9	1303.4	1.13
Gravel/Quarry	14.6	238.8	16.33
Interstate	49.0	8.7	0.18
Total	29809.5	100972.6	3.39

*C: Corn; S: Soybean; W: Wheat; M: Meadow

The corn-soybean rotation had the highest average erosion 7.6 tons/ac and C-C-S-W-M-M-M-M had 2.5 tons/ac. The range in erosion is partially the result of increased surface cover associated with the meadow portion of the rotation.

Sedimentation Survey

The sounding data from the 1981 survey was used to calculate the 1961 and 1981 storage capacities of the lake at the spillway level. The difference between these storage capacities is the lake volume that was lost to sedimentation since 1961. Bogner (1982) calculated that Highland Silver Lake has lost 13.6% of its original capacity as a result of sedimentation between 1961 and 1981 (0.69% per year).

The total weight of sediment within the lake was calculated to be 866,000 tons (Bogner, 1982). The average annual sediment deposition in the lake for the past 19.7 years (1961-1981) was calculated to be 43,959 tons. Particle size distribution of four bottom sediment samples was determined during the sedimentation survey.

DISCUSSION

In this study, the total amount of gross erosion was estimated on the watershed. Gross erosion computations by the soil loss equation and direct volume method did not include channel-type erosion; this is being computed separately and is not included in this analysis. The stream geometry and channel characteristics monitoring consist of two parts: 1) monitoring channel dynamics; and 2) analyzing particle size distribution of bed material at certain stream location after rainfall events. The cross section were measured in 1981 and will be measured in 1984 to show changes in the stream cross section due to deposition and scouring. The monitoring of channel dynamics consisted of determining cross sectional area of the channel at 70 locations. Determining deposition and scouring in the channel at 70 locations combined with the particle size distribution analyses of bed material at eleven sites in the channel will enable the contribution of bed material to the total suspended load to be estimated. The results of this monitoring will be incorporated into the final report on soil erosion and sediment delivery.

Potential gross erosion for the Highland Silver Lake Watershed is estimated to be 100,973 tons/year; 3.4 tons/ac/year. Average values can be misleading. On the surface it appears that erosion would not be a serious problem within the watershed, but some fields had average erosion rates of over 40 tons/ac/year.

Soil particles are often detached and transported for only a short distance in any one storm but may ultimately reach the watercourse after repeated storms. Moore et al (1977) referred to this phenomena as the "play fairs" law, implying that sooner or later sediment deposited in concentrated flow channels will reach streams or lakes. Trimble (1975) has reported that sediment deposited in stream channels will move downstream as upstream loading decreases. The location of monitoring stations on Little Silver Creek should enable confirmation of this process (Figure 6).

Figure 4. Location and severity of potential soil erosion in the Highland Silver Lake Watershed.

The source area of runoff in a watershed expands and contracts according to rainfall rates and the capacity of the soil to retain and release waters (Dunne, 1978). This variable source concept has important implications for the understanding of sediment source areas because it provides a model explaining how a channel network grows to many times its average perennial dimensions during storm runoff as streams become both longer and wider, thus allowing a larger area to contribute to the total basin sediment yield than during baseflow periods. The variable source concept applies to Little Silver Creek Watershed because infiltration is not a limiting factor. If surface runoff is generated from a small portion of the watershed close to the channel network or lake, the area of significance for sediment yield will be limited to this contributing area. This concept is referred to as the "partial area" theory. Thus, all lands are considered to contribute or yield proportionate shares.

Distance of travel is important due to settling relationships between streams carrying capacity and total suspended load. The parameters which influence this sediment yield, and therefore the sediment delivery ratio, are: the size of the drainage area, the number of the stream channels (stream density), the gradient of the stream channels, the size and density of the sediment particles, the stream channel roughness and the soil, topographic and weather parameters that control the magnitude and duration of stream flow. The stream network cannot be viewed as a static force. The acceptance of the dynamic character of both soil erodibility, erosion processes, of the contributing area and stream channel networks within the watershed necessarily means sediment entrainment is very time and event variant (Walling, 1977).

The relative efficiency of the various erosion processes upon yield to the lake varies by season and location within the watershed. The sediment delivery ratio for each process was not calculated or estimated. The delivery ratios may differ significantly for the sediments from the two types of sources (gully and streambank/sheet and rill). Channel erosion produces sediment that is immediately available to the transport system, much of it tends to remain in motion as bedload and suspended sediment. The principal hydrologic factors that affect channels are surface runoff and sediment yield (Leedy, 1979). Surface runoff, which is dependent upon climate, vegetation, infiltration capacity, gradient and the cross-sectional capacity of the stream (Morisawa, 1968). The sediment yield of a drainage basin is the resultant of the processes of erosion, transportation and deposition operating in that basin, and its magnitude reflects the sediment delivery ratio (Davenport, 1982). Sediment yield controls the channel pattern and aspects of channel geometry, such as the depth - width ratio (Morisawa, 1968).

The partial area and variable source area concepts pertaining to storm runoff production have very important implications for sediment source areas and erosion processes. The bulk of erosion and transportation of sediments from upland sites is related to a very small number of

hydrologic events. Most of the sediment transported by streamflow is carried during a few large storm events. A substantial reduction in the amount of sediment delivered to a stream may result in a compensatory increase in channel erosion. However, the composition of sediment derived from channel erosion will usually differ substantially from that derived from sheet and rill erosion from cropland. The particle size analysis component of the stream geometry and channel characteristic monitoring will enable detection of this phenomenon if it should occur.

Livestock grazing and watering has a pronounced effect on the stream bank environment and hence also on the sediment delivery into adjacent streams. Marcuson (1977) found that reduced vegetation as a result of grazing produced poorer soils and led to 80% more stream channel alteration than in ungrazed sections. Within the grazed area, the stream channel was found to be wider, shallower and continually in migration.

SEDIMENT DELIVERY RATIO

The lake sedimentation survey of Highland Silver Lake (Bogner, 1982) indicated the average annual sediment deposition in the lake for the past 19.7 years (1961-1981) was 43,959 tons.

The arithmetic average of sediment production rates obtained from about 1,100 measurements throughout the United States for various sizes of drainage areas is shown in Table 4. The average for the Highland Silver Lake Watershed is 1.07 acre-ft/square mile (Bogner, 1982). This is lower than the National average.

TABLE 4

Arithmetic Average of Sediment - Production Rates
for Drainage Areas in the United States (Gottschalk, 1964)

Watershed-size range, sq. mile	No. of Measurement	Average annual sediment-production rate, acre-ft/sq mile
Under 10	650	3.80
10-100	205	1.60
100-1,000	123	1.01
Over 1,000	118	0.50

The annual runoff of the Highland Silver Lake Watershed is estimated to be 533 acre-feet per year per square mile (Boland, 1979). With a drainage area of 47.5 square miles, excluding the lake area, the annual inflow into Highland Silver Lake is 25,317 acre-feet. Sefton (1980), showed the capacity to be 5,500 acre-feet. Therefore, the capacity-inflow ratio (C/I) becomes 0.217. From the Brune trap efficiency curve, (Linsley, 1975) the trap efficiency is estimated to 93%.

Therefore, the annual sediment yield of the Highland Silver Lake Watershed is 47,268 tons (43,959/0.93). The delivery ratio, which is the ratio of sediment yield to the gross erosion (47,268/100,973), is calculated to be 47%.

Table 5, shows that sediment delivery ratios by drainage area. The Highland Silver Lake Watershed's sediment delivery is 111% higher than is estimated in Table 5. The high sediment delivery ratio found in the Highland Silver Lake Watershed is due to: 1) the eroding soil is very high in silt, and 2) high channel density, these factors combine for very efficient transport of eroded material.

TABLE 5

Sediment Delivery Ratio by Drainage Area. (Stewart, 1976)

Drainage Area (Square Miles)	Sediment Delivery (Ratio)
0.5	0.33
1	0.30
5	0.22
10	0.18
50	0.12
100	0.10
200	0.08

The sediment deposition ratio can be calculated by determining the tons of sediment deposited divided by the total tons of erosion occurring within the watershed. Bogner (1982) determined that average annual tons of sediment deposited to be 43,959 tons. Gates (1982) estimated gross erosion to be 100,973 tons. Lake sedimentation data is then correlated with estimated gross erosion to determine a sediment deposition ratio of 43.5%.

Changes in the sediment delivery ratio are likely, due to changes in the sediment source area. A substantial reduction in the amount of sediment delivered to a stream may result in a compensatory increase if channel erosion produces sediment that is immediately available to the transport system. Whereas sediment from cropland must first get to the stream before it can be transported (Davenport, 1982B). There has been a substantial change in agricultural management on the watershed since the reservoir was constructed in 1961; the switch from pasture (grasses) to row crop is the dominant change and more intensive row cropping. The RCWP is being targeted toward treating the critical agricultural land. Reduction in soil erosion does not always produce visible improvements in water quality since silt and clay particles are the hardest to control and yet contribute the most to water color and turbidity. Knox, (1977) concluded that land use not only exerts a strong contemporary influence on associated rates of surface runoff and sediment yields, but it may indirectly affect watershed processes and sediment yields of subsequent periods as channel systems attempt to reestablish an equilibrium with new watershed conditions. The improved land use or watershed conservation practices results in erosion of sedimentary deposits that accumulated during preceding periods of high yields (Trimble, 1976; Happ, 1940), this a version of the exhaustion effect illustrated earlier.

An annual rate of reservoir capacity loss nomograph based on only two parameters: 1) the reservoir capacity expressed in inches on the drainage area, and 2) the size of the drainage area in square miles, can be used to estimate annual capacity loss for a particular proposed reservoir. A determination of the accuracy of this nomograph showed that the annual capacity loss determined will not be more than 60% in error in either direction (Stall, 1964). Using this nomograph annual capacity loss was determined to be 0.43% for Highland Silver Lake. Currently, it is estimated to be 0.69% per year of capacity lost to sedimentation; this is close to the median sedimentation rates (0.60) in other Illinois reservoirs (Roseboom, 1978). The highest and lowest sedimentation rates measured by ISWS in 101 reservoirs are 5.67 and 0.15% per year respectively (kothandasaman, 1982). This is 32% lower than the loss calculated using Bulletin 51 and it is within the 60% accuracy limit.

The results of the 1981 survey indicate that the sedimentation is 0.69% from 1961-1981 (Bogner, 1981). The median storage depletion for all U.S. reservoirs is 1.5% per year (McDowell, 1976). Highland Silver Lake's rate is less than half the National average.

EXTRAPOLATION OF RESULTS

Table 4 summarizes the potential soil erosion estimates under most practical, most likely, and best possible management conditions as determined by the ADAPT system. These three management conditions were defined by local USDA personnel.

Most practical conditions are those land management activities possible under the USDA-RCWP. Most likely conditions are land management conditions most likely to be implemented under the RCWP. Best possible conditions are the best land management conditions possible for that land management unit. All of these management conditions were defined in the manner described in the methods section.

Comparison of these scenarios showed several trends. First, there were no major land use shifts between the scenarios, second there were no major shifts in crop rotation between the scenarios, third, there is a substantial decrease in the total erosion and fourth there is an increase in the percent of area meeting "T" from the present conditions. These trends indicate that the amount of sediment being deposited in Highland Silver Lake would be reduced because the potential gross erosion decreased between management scenarios. However, soil erosion is not synonymous with soil loss, nor is soil loss with sediment yield. Under "most practical", "most likely" and "best possible" potential gross erosion is reduced by 46%, 27%, and 59% respectively. Clearly, the proposed conservation practices under the various management conditions produce substantial decreases in total potential gross erosion. This has important implication for Highland Silver Lake because a significant decrease in gross erosion would decrease the rate of which the lake is filling with sediment, thereby extending its life.

Reduction in soil delivery does not always produce visible improvements in water quality since silt and clay particles appear to be the hardest

to control and yet contribute the most to water color and turbidity problems. Clay-size soil particles, while not necessarily the easiest to detach, are more easily transported than the larger soil particles. Majority of the soil within the watershed is classified as Nutric, which means it is influenced by sodium. The sodium causes the soil particles to detach and breakup easier and go into solution. Once in solution the particles remain suspended longer than the larger ones. Bogner (1982) showed that as the water moves through Highland Silver Lake, the sediment carried in suspension becomes finer and finer as the coarser materials settle out in the upper reaches of the Lake. This means the particles having the greatest impact upon water quality are still in suspension and have not settled out, this is approximately 7% of the delivered load.

Since the clay size particles remain in suspension they must be kept in place. Therefore, those RMS's which control the detachment and transport of clay-size particles should be recommended. Those practices that control splash and interrill erosion will be highly effective at controlling detachment of clay-size particles. Practices which increase ground cover are most effective at reducing splash and interrill erosion. Walter (1977) provides the following list of effective practices: strip cropping, conservation (minimum) tillage, winter cover crops, contour listing, and ridge planting. RMS's must be implemented that also disrupt the clay-size particle transport mechanisms, either the runoff volume or its velocity must be reduced. Walter (1977) and Mueller (1981) state that conservation (minimum) tillage can greatly reduce splash and interrill erosion as well as runoff volume and velocity. Walter (1977) also provides evidence that contour listing, ridge planting, strip cropping and winter cover crops control both the detachment and transport of clay-size particles.

The lake sedimentation survey (Bogner, 1982) determined that on an average 43,954 tons of sediment were deposited in the lake each year for the past 19.7 years. This meant that the annual rate of lake capacity lost to sedimentation was 0.69% per year. At this rate, Highland Silver Lake would be completely filled in 145 years. However, under most practical conditions only 25,485 tons would be delivered to the lake and only 23,701 tons would be deposited in Highland Silver Lake itself. This is a reduction of 46% from the current amount. Under this condition, the rate of depletion of original storage would be reduced 0.37% per year. Therefore, the life of the lake would be extended to 270 years, a gain of 125 years.

Under "most likely" conditions 34,448 tons of sediment are transported and 32,037 tons deposited in Highland Silver Lake. The amount of sediment deposition would be reduced by 0.27%. Under this condition, the rate of depletion of original storage would be reduced to 0.50% per year. The life of the lake would be extended 199, a gain of 54 years. Under "best possible" conditions 19,395 tons of sediment are transported and 18,037 tons deposited in the lake. The amount of sediment deposited under present conditions would be reduced by 59%. By implementation of the "possible best" conservation practices, the annual rate of lake

TABLE 6

Acres, Erosion and Percent of Area Meeting "T" by Land Management Activity
for the Most Practical, Most Likely and Best Possible Management Scenario as Determined by the ADAPT System.

	Most Practical				Most Likely				Best Possible			
Land Management Activity*	No. of Acres	Erosion (Tons)	Erosion (Tons/AC)	% of Area Meeting T	No. of Acres	Erosion (Tons)	Erosion (Tons/AC)	% of Area Meeting T	No. of Acres	Erosion (Tons)	Erosion (Tons/AC)	% of Area Meeting T
Corn-Soybeans	457.4	1900.7	4.16	59.2	457.4	1903.5	4.16	58.7	402.2	1335.2	3.32	66.0
C-S-W/DBL. Crop Soybeans	17849.6	36914.7	2.07	87.9	17971.2	52639.6	2.93	66.8	17432.2	26518.4	1.52	95.6
S-W/DBL. Crop Soybeans	2093.1	3843.2	1.84	96.1	2093.1	3905.6	1.87	95.3	2068.8	3538.1	1.71	96.5
C-S-W-M	2842.1	3987.6	1.40	96.9	2895.3	6217.3	2.15	85.5	2669.2	2946.5	1.10	98.9
C-C-S-W-M-M-M-M	1749.7	2563.7	1.47	93.6	1615.0	3069.5	1.90	89.7	2200.8	1767.5	0.80	98.8
Perm. Grassland (Good)	1808.2	731.9	0.40	100.0	1296.4	576.2	0.44	100.0	1983.6	838.7	0.42	100.0
Woodland (managed)	1275.2	211.3	0.17	100.0	1011.1	153.8	0.15	100.0	1275.2	211.3	0.17	100.0
Woodland (unmanaged)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wildlife	363.9	487.0	1.34	97.1	325.0	458.5	1.41	96.7	398.2	512.8	1.29	97.3
Urban Areas	210.3	112.6	0.54	100.0	210.3	112.6	0.54	100.0	210.3	112.6	0.54	100.0
Feedlots	116.3	2019.2	17.36	1.7	116.3	2019.2	17.36	1.7	116.3	2019.2	17.36	1.7
Farmsteads	618.8	927.7	1.50	94.5	656.8	1000.0	1.52	94.8	618.8	927.7	1.50	94.5
Residential (low dens.)	355.9	269.9	0.76	99.5	557.3	488.3	0.88	98.4	355.9	269.9	0.76	99.5
Perm. Grassland (Poor)	5.3	6.0	1.13	100.0	540.7	502.4	0.93	99.4	14.4	20.1	1.40	100.0
Gravel/Quarry	14.6	238.8	16.33	17.0	14.6	238.8	16.33	17.0	14.6	238.8	16.33	17.0
Interstate	49.0	8.7	0.18	100.0	49.0	8.7	0.18	100.0	49.0	8.7	0.18	100.0
Total	29809.5	54222.6	1.82	90.6	29809.5	73294.1	2.46	76.4	29809.5	41265.3	1.38	96.0

*C: Corn; S: Soybean; W: Wheat; M: Meadow; /: Double Crop

capacity lost to sedimentation is reduced to 0.28% per year, meaning that the life of the lake would be extended 353 years, a gain of 208 years. It should be noted that the lake would never completely fill up and that the useful life of the lake is significantly less than the time it would take to fill it up.

It should be noted, however, these numbers are only valid if the various management scenarios are put into practice immediately, and if the sediment delivery ratio and trap efficiency of the lake remains constant. Changes in the sediment delivery ratio are likely due to changes in the sediment source areas. As noted earlier, a substantial reduction in the amount of sediment delivered to stream results in a compensatory increase in channel erosion. Channel erosion produces sediment that is immediately available to the transport system, whereas sediment from crop land must first get to the stream before it can be transported. Changes in the trap efficiency are likely as sediment accumulates within the lake thereby decreasing lake storage volume and lowered residence time.

CONCLUSIONS

1. Potential gross erosion for the Highland Silver Lake Watershed is estimated to be 100,973 tons/year.

2. The gross erosion rate from the watershed was combined with lake sedimentation data from Highland Silver Lake to determine a sediment delivery ratio for the watershed. This ratio was calculated to be 47%.

3. Any reduction in soil erosion due to improved land management practices would lead to a reduction in material delivered to the lake.

4. Currently, 0.69% per year of lake capacity is lost to sedimentation. This is 32% lower than the loss calculated using Bulletin 51 (Stall, 1964).

5. The finer material is remaining in suspension, therefore, practices which control splash and interrill erosion, as well as runoff volume and velocity should be recommended to the land owner/operators within the Highland Silver Lake Watershed. Conservation tillage is one such practice.

6. If under present conditions the lake could be completely filled, it would take 145 years. Under "most practical", "most likely" and "best possible" conditions the life of the lake would be 270,199, and 353 years respectively. The lake would never completely fill up and the useful life of the lake would be significantly less than these calculated values.

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APPENDIX SECTION

Appendix A

HIGHLAND SILVER LAKE RCWP PROJECT
APPROVED BMP's
ILLINOIS

BMP-1 Permanent Vegetative Cover (cost-share level 75%)

Components:
382 - Fencing
510 - Pasture and hayland management
512 - Pasture and hayland planting

BMP-2 Animal Waste Control System (cost-share level 75%)

Components:
312 - Waste management systems
313 - Waste storage structure
342 - Critical area planting
359 - Waste treatment lagoon
362 - Diversion
382 - Fencing
393 - Filter strips
412 - Grassed waterway or outlet
425 - Waste storage pond
442 - Irrigation system, sprinkler
443 - Irrigation system, surface and subsurface
606 - Subsurface drain
633 - Waste utilization

BMP-4 Terrace System (cost-share level 75%)

Components:
500 - Obstruction removal
600 - Terrace
606 - Subsurface drain
620 - Underground outlet

BMP-5 Diversion System (cost-share level 75%)

Components:
362 - Diversion
606 - Subsurface drain
620 - Underground outlet

BMP-7 Waterway System (cost-share level 75%)

Components:
382 - Fencing
412 - Grassed waterway or outlet
468 - Lined waterway or outlet
606 - Subsurface drain

BMP-8 Cropland Protective System (cost-share level 75%)

Component:
340 - Cover and green manure crop

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BMP-9* Conservation Tillage System (cost-share level 75%)

Components:
329 - Conservation tillage system
330 - Contour farming
344 - Crop residue use*

BMP-10 Stream Protection System (cost-share level 75%)

Components:
382 - Fencing
393 - Filter strip
580 - Streambank protection

BMP-11 Permanent Vegetative Cover on Critical Areas (cost-share level 75%)

Components:
342 - Critical area planting
382 - Fencing
386 - Field border
393 - Filter strips
472 - Livestock exclusion
484 - Mulching

BMP-12 Sediment Retention, Erosion or Water Control Structures (cost-share level 75%)

Components:
350 - Sediment basin
382 - Fencing
410 - Grade stabilization structure

BMP-14 Tree Planting (cost-share level 75%)

Components:
382 - Fencing
612 - Tree planting

BMP-15 Fertilizer Management (cost-share level 75%)

Components:
384 - Fertilizer management
633 - Waste utilization

Appendix B

"C" FACTORS

			Residue After Planting				
	Fall Plow	Spring Flow	20%	30%	40%	60%	80%
0 C-sb	.41	.35	.28	.23	.20	.18	.10
1 C-sb-w/sb	.30	.23	.17	.15	.12	.08	.05
2 Sb-w/sb	.27	.11	.15	.13	.12	.07	.04
3 C-sb-w-m	.18	.15	.11	.09	.08	.06	.05
4 C-c-sb-w-m-m-m-m	.14	.11	.09	.08	.07	.05	.03

	"C" Factor
5 Permanent grassland (good condition) -	.013
5b Permanent grassland (poor condition) -	.042
6 Woodland - managed -	.003
7 Woodland - unmanaged -	.025
8 Wildlife -	.038
9 Urban areas -	.013*
10 Feedlots -	.80
11 Farmsteads -	.042*
12 Residential - low density -	.013*

*Estimated "C" factors based on factors for permanent pasture land.

c; corn
sb; soybeans
w; wheat
m; meadow
/; double crop

Appendix C

"P" VALUES

Contouring:

Land Slope Percent	P Value
1 to 2	0.60
3 to 8	0.50
9 to 12	0.60
13 to 16	0.70
17 to 20	0.80
21 to 25	0.90

Contouring Stripcropping:

Land Slope Percent	P Value
3 to 8	.30
9 to 16	.45
17 to 20	.80
21 to 25	.90

Appendix D

Soils Information Utilized in the ADAPT Data Base

ADAPT #	SCS #	SOIL NAME	SLOPE LENGTH	K	T	HYD. SOIL GROUP
1	8E3	Hickory cl	100'	.37	5	C
2	8F	Hickory sil	75'	.37	5	C
3	119B2	Elco	200'	.37	5	B
4	119C3	Elco sicl	200'	.37	5	B
5	119D2	Elco sil	180'	.37	5	B
6	119D3	Elco sicl	180'	.37	5	B
7	279C2	Rozetta sil	200'	.37	5	B
8	279C3	Rozetta sicl	200'	.37	5	B
9	280C2	Fayette sil	200'	.37	5	B
10	280D2	Fayette sil	180'	.37	5	B
11	280F	Fayette sil	120'	.37	5	B
12	279D3	Rozetta sicl	150'	.37	5	B
13	581B2	Tamalco sil	300'	.43	3	D
14	583C2	Pike sil	250'	.37	5	B
15	583D2	Pike sil	250'	.37	5	B
16	585E	Negley l	100'	.32	3	B
17	620B	Darmstadt sil	200'	.43	3	D
18	620B2	Darmstadt sil	200'	.43	3	D
19	620B3	Darmstadt sicl	200'	.43	3	D
20	620C3	Darmstadt sicl	150'	.43	3	D
21	914C3	Atlas-Grantfork	150'	.32	2	D
22	914D3	Atlas-Grantfork	120'	.32	2	D

ADAPT #	SCS #	SOIL NAME	SLOPE LENGTH	K	T	HYD. SOIL GROUP
23	916B	Darmstadt-Oconee sil complex	300'	.41	3	D
24	916B2	Darmstadt-Oconee sil complex	300'	.41	3	D
25	936D2	Fayette-Hickory complex	120'	.37	5	B
26	936F	Fayette-Hickory complex	100'	.37	5	B
27	937F	Hickory-Gosport complex	100'	.37	5	C
28	993	Cowden-Piasa sl complex	300'	.37	3	D
29	916A	Darmstadt-Oconee sil complex	300'	.41	3	D
30	995	Herrick-Piasa sil complex	300'	.34	4	C
31	941	Virden-Piasa sil complex	200'	.32	5	C
32	46	Herrick sil	250'	.32	4	C
33	620A	Darmstadt sil	300'	.43	3	D
34	920	Rushville-Huey sil	250'	.43	3	D
35	113B	Oconee sil	200'	.37	3	C
36	17A	Keomah sil	200'	.37	5	C
37	17B	Keomah sil	250'	.37	5	C
38	120	Huey sil	300'	.43	2	D
39	334	Birds sil	250'	.43	5	C
40	428	Cofeen sil	120'	.32	5	B
41	243B	St. Charles sil	200'	.37	5	B
42	127B	Harrison sil	200'	.32	5	C
43	41B	Muscatine sil	200'	.28	5	B
44	48	Ebbert sil	150'	.35	5	D
45	415	Orion sil	200'	.28	5	B

Appendix D (continued)

ADAPT #	SCS #	SOIL NAME	SLOPE LENGTH	K	T	HYD. SOIL GROUP
46	451	Lawson sil	150'	.32	5	B
47	333	Wakeland sil	200'	.35	7	B
48	214B	Hosmer sil	250'	.43	4	C
49	165	Weir sil	200'	.43	4	D
50	50	Virden sicl	250'	.28	5	C
51	46A	Herrick	250'	.28	5	C
52	47A	Piasa	200'	.37	3	D
53	16	Rushville	200'	.43	3	D
54	37A	Wirthen	300'	.32	5	B
55	583B	Pike sil	250'	.37	5	B
56	620	Darmstadt	200'	.43	3	D
57	68	Sable	200'	.28	5	D
58	R453B	Rozetta	250'	.37	5	B
59	70	Beaucoup sicl	300'	.32	5	B
60	127C2	Harrison	200'	.32	5	C
61	120B	Huey	250'	.43	2	D
62	279B	Rozetta	250'	.37	5	B
63	278A	Stronghurst	300'	.37	5	B
64	278B	Stronghurst	250'	.37	5	B
65	280B	Fayette	180'	.37	5	B
66	801	Orthents, silty	120'	.43	5	C
67	802	Orthenta, loamy	120'	.37	5	B
68	865	Gravel pits	200'	.10	5	A
69	993	Cowden-Piasa sil (same as ADAPT #28)	300'	.37	3	D

Appendix E

NUMERICAL ASSIGNMENTS FOR CODING OF SCENARIOS

1st Number - Rotations

0 - Corn, soybeans

1 - Corn, soybeans, wheat/double crop soybeans

2 - Soybeans, wheat/double crop soybeans

3 - Corn, soybeans, wheat, meadow

4 - Corn, corn, soybeans, wheat, meadow, meadow, meadow, meadow

5 - Permanent grassland (good condition)

5b - Permanent grassland (poor condition)

6 - Woodland - managed

7 - Woodland - unmanaged

8 - Wildlife

9 - Urban areas

10 - Feedlots

11 - Farmsteads

12 - Residential - low density

2nd Number - Tillage Practices

0 - Not cropland

1 - Moldboard plow - spring

2 - Moldboard plow - fall

3 - Conservation tillage (chisel plow) - 20% residue after planting

4 - Conservation tillage (chisel plow) - 30% residue after planting

5 - Conservation tillage (chisel plow) - 40% residue after planting

6 - No-Till - 60% residue after planting

7 - No-Till - 80% residue after planting

Appendix E (continued)

NUMERICAL ASSIGNMENTS FOR CODING OF SCENARIOS

3rd Number - Conservation Practices

0 - No practice

1 - Contouring

2 - Terraces

3 - Stripcropping (contour)

4 - Pasture management or critical area seeding

5 - Livestock exclusion

6 - Animal waste system

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